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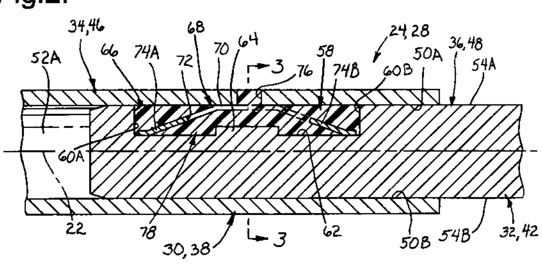
(54) Variable length shaft assembly.

(57) A variable length shaft assembly (24,28) including a first shaft (30,38) having a polygonal tubular end (34,46); a second shaft (32,42) having a correspondingly polygonal solid end (36,48) telescopically disposed in the polygonal tubular end; an arched spring (68) in a spring chamber (66) in the polygonal solid end having a planar body portion (70) bearing in sliding engagement on a planar wall (50A,B) of the polygonal tubular end and biasing the polygonal solid and tubular ends in opposite directions to a substantially zero clearance relationship in which linear clearances are reduced to substantially zero, and a monolithic plastic block (78) injection moulded in situ in the spring chamber behind the flat body portion. After the in situ injection moulded plastic solidifies, the monolith plastic block captures the substantially zero clearance relationship between the polygonal solid and tubular ends and encases the arched spring such that the flat body portion thereof defines a reinforced wear plate on the block in sliding engagement on the planar wall of the tubular polygonal end.

Fig.2.



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This invention relates to variable length shaft assemblies in motor vehicle steering systems.

US Patent No. 3,457,799, describes a motor vehicle steering column having a column shaft assembly for transferring steering torque and including a first shaft having a polygonal solid end telescopically disposed in a correspondingly polygonal tubular end of a second shaft. Plastic is in situ injection moulded into a clearance between the polygonal ends and into a transverse bore through the ends. When solidified, the plastic effects an angularly and linearly rigid connection between the polygonal ends which persists until the steering column experiences an energy absorbing collapse event during which the plastic in the clearance between the shaft ends defines a bearing for minimising friction. In applications where the column shaft assembly normally experiences repeated extend/retract cycles, e.g. a length adjustable steering column, an in situ injection moulded bearing such as described in the aforesaid US Patent No. 3,457,799 may be susceptible to wear and abrasion.

US Patent No. 4,509,775, describes an intermediate shaft assembly for transferring steering torque between a column shaft assembly and a steering gear in a motor vehicle steering system. The intermediate shaft assembly includes a first shaft having a polygonal solid end telescopically disposed in a correspondingly polygonal tubular end of a second shaft and an arched spring in a cavity in the solid end bearing against a wall of the tubular end. The spring urges the polygonal ends in relative linear separation to a substantially zero linear clearance relationship for torque transfer without angular lash. During multiple extend/retract cycles characteristic of intermediate shaft assemblies in motor vehicle steering systems, the spring maintains the zero clearance relationship between the shaft ends while sliding back and forth relative to the wall of the tubular end.

A shaft assembly according to this invention is particularly suited for torque transfer in applications where multiple extend/retract cycles are normally experienced and is an improvement over the shaft assemblies described in the aforesaid US Patent Nos. 3,457,799 and 4,509,775.

A variable length shaft assembly is accordance with the present invention is characterised over US 4,509,775 by the features specified in the characterising portion of Claim 1.

This invention is a new and improved variable length shaft assembly for a motor vehicle steering system and includes a first shaft with a polygonal solid end telescopically disposed in a correspondingly polygonal end of a second shaft and with an arched spring disposed in a cavity in the solid end having a flat side bearing against a planar wall of the tubular end. In a predetermined linear position of the tubular end relative to the solid end, an orifice in the tubular end registers with a slot in the flat side of the arched spring and co-operates therewith in defining a passage through which plastic is in situ injection moulded into the cavity in the solid end behind the arched spring. When solidified, the in-situ injection moulded plastic defines a monolithic block around the arched spring having physical characteristics including high Young's Modulus, to capture the substantially zero linear clearance relationship between the tubular and solid ends for effectively lash-free torque transfer therebetween, and low coefficient of friction, for minimising resistance to relative telescopic movement during multiple extend/retract cycles of the shaft assembly. The flat side of the arched spring is exposed on the side of the monolithic plastic block facing the planar wall of the tubular shaft end and defines a wear plate on the plastic block for maximising durability.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a fragmentary schematic view of a motor vehicle steering system having a column shaft assembly according to this invention and an intermediate shaft assembly according to this invention;

Figure 2 is a fragmentary longitudinal sectional view of the shaft assemblies of Figure 1;

Figure 3 is a sectional view taken generally along the plane indicated by lines 3-3 in Figure 2;

Figure 4 is a fragmentary exploded perspective view of the shaft assemblies of Figure 1; and

Figure 5 is a partially broken-away perspective view of a portion of Figure 2.

Referring to Figure 1, a fragmentarily illustrated motor vehicle steering system 10 includes a representative steering gear 12 having an input shaft 14 rotatably supported on a housing 16 of the steering gear. The housing 16 is mounted on a chassis, not shown, of the motor vehicle outside of a passenger compartment thereof and contains internal rack and pinion gearing which converts rotation of the input shaft 14 to linear bodily movement of a steering rack connected in conventional fashion to steerable wheels, not shown, of the motor vehicle.

A steering column 18 of the steering system 10 includes a tubular mast jacket assembly 20 having an adjustable or variable length dimension L in the direction of a longitudinal centreline 22 of the steering column. A variable length column shaft assembly 24 according to this invention is supported on the mast jacket assembly 20 for rotation about the centreline 22. A steering wheel 26 is rigidly attached to the column shaft assembly 24 at the one end of the mast jacket assembly. At the other end of the mast jacket assembly 20, outside the passenger compartment, the column shaft assembly 24 is connected to the input shaft 14 of the steering gear by a variable length intermediate shaft assembly 28 according to this invention.

The column shaft assembly 24 includes a first shaft 30 to which the steering wheel 26 is rigidly attached and a second shaft 32 to which the intermediate shaft assembly 28 is connected. The first shaft 30 has a non-cylindrical or polygonal tubular end 34 in which is telescopically disposed a correspondingly non-cylindrical or polygonal solid end 36 of the second shaft 32. The telescopically related solid and tubular ends 34,36 transfer steering torque between the first and second shafts 30,32 while accommodating concurrent variation in the length of the column shaft assembly 24 in accordance with changes in the length dimension L of the mast jacket assembly 20.

The intermediate shaft assembly 28 includes a first shaft 38 connected to the second shaft 32 of the column shaft assembly through a first universal joint 40 and a second shaft 42 connected to the input shaft 14 through a second universal joint 44. The first shaft 38 has a non-cylindrical or polygonal tubular end 46, identical to the tubular end 34 on the first shaft 30 of the column shaft assembly 24, in which is telescopically disposed a correspondingly non-cylindrical or polygonal solid end 48 of the second shaft 42, identical to the solid end 36 on the second shaft 32 of the column shaft assembly.

The telescopically related solid and tubular ends 48,46 transfer steering torque between first and second shafts 38,42 of the intermediate shaft assembly 28 while accommodating concurrent cyclic variation in the distance separating the bottom of the column shaft assembly 24 from the input shaft 14 which variation results from small excursions of relative movement between the chassis and the passenger compartment of the vehicle. Also, the telescopically related solid and tubular ends 48,46 accommodate length adjustment of the intermediate shaft assembly 28 associated with installing the latter in the motor vehicle steering system 10.

Referring to Figures 2-4, the polygonal tubular ends 34,46 are defined by flattening the first shafts 30,38, respectively, on opposite sides and each includes a pair of parallel planar walls 50A-B interconnected by a pair of integral arcuate walls 52A-B. The correspondingly polygonal solid ends 36,48 are defined by flattening the second shafts 32,42 on opposite sides and each includes a pair of parallel planar sides 54A-B and a pair of arcuate sides 56A-B.

The solid ends 36,48 are received in the tubular ends 34,46, respectively, such that the solid and tubular ends are freely telescopically bodily shiftable relative to each other. Relative rotation between the solid and tubular ends 36,34 and 48,46 is restricted by interference between the planar walls 50A-B and the facing ones of the planar sides 54A-B. Because of linear clearances between the solid and tubular ends 36,48,34,46 necessary to minimise sliding friction therebetween and because of manufacturing tolerances, the solid and tubular ends are rotatable relative to each other through a small angular interval, commonly referred to as angular "lash", before interference between the planar walls 50A-B and planar sides 54A-B effects unitary rotation thereof. Such angular lash is usually on the order of about 1.2 degrees.

As seen best in Figures 2-5, the solid ends 36,48 each include a cavity 58 therein having a pair of side walls 60A-B perpendicular to the planar sides 54A-B and a bottom wall 62 parallel to the planar sides 54A-B. A transverse raised boss 64 is defined on each bottom wall 62. The cavities 58 are each open through the corresponding planar side 54A and at opposite ends through the arcuate sides 56A-B. With the solid ends 36,48 telescopically disposed in the tubular ends 34,46, respectively, the cavities 58 each define a spring chamber 66 closed on three sides by the bottom wall 62 and the side walls 60A-B and on three other sides by the planar wall 50A and the arcuate walls 52A-B of the tubular ends 34,46.

An arched spring 68 is disposed in each spring chamber 66 and includes a flat body portion 70 perforated by a slot 72 and a pair of integral curved legs 74A-B bearing against the bottom wall 62 of the corresponding cavity 58. A height dimension H, Figure 4, of each spring 68 in an unflexed condition thereof exceeds the depth of the corresponding cavity 58 so that the flat body portion 70 of each spring is outside or outboard of the plane of the corresponding planar side 54A when the spring is unflexed, that is prior to introduction of the solid ends 36,48 into the tubular ends 34,46.

When the solid ends 36,48 are introduced into the tubular ends 34,46, respectively, an edge of each tubular end engages the leg 74A of the corresponding arched spring 68 and cams the flat body portion 70 into sliding engagement on the planar wall 50A of the tubular end. With the springs 68 thus compressed or flexed, the flat body portion 70 of the springs bear in sliding engagement against the planar walls 50A of the corresponding tubular ends 34,46 and urge the telescopically related shaft ends in opposite linear directions perpendicular to the planar sides 54A-B and planar walls 50A-B. In that circumstance, linear clearances between the tubular ends 34,46 and the solid ends

36,48 are reduced to substantially zero.

The tubular ends 34,46 each have an orifice therein defining an injection port 76 which, in a predetermined longitudinal position of the solid ends 36,48 relative to the tubular shaft ends, Figures 2-3, registers with the slot 72 in the corresponding spring 68. While the springs 68 maintain substantially zero linear clearance between the ends 34,46,36,48, in situ injection moulding apparatus, not shown, injects plastic in liquid form into the spring chambers 66 behind the springs 68 through passages defined by the injection ports 76 and the slots 72.

Other passages for introducing liquid plastic into the spring chambers 66 behind the flat body portion 70 of the springs 68 are contemplated. For example, an injection port corresponding to the injection ports 76 may be located on the opposite planar wall of the tubular ends 34,46 from the injection ports 76 in the preferred embodiments. In such an alternate embodiment, flow communication between the injection port and the spring chamber 66 is effected through a bore, not shown, in the corresponding solid end 36,48.

The liquid plastic fills each spring chamber 66 and, upon solidification, defines a monolithic block 78 therein capturing the substantially zero clearance relationships between the ends 34,46 and 36,48 as well as encapsulating the springs 68. With the injection ports 76 in register with the slots 72, the liquid plastic does not migrate between the flat body portions 70 of the springs 68 and the corresponding planar walls 50A of the tubular ends so that the flat body portions 70 of the springs 68 are exposed, Figure 5, and define reinforced wear plates on each block which minimise abrasion under multiple or continuous cycles of relative telescopic movement between the solid 36,48 and tubular 34,46 ends. The boss 64 on the bottom wall 62 maintains generally constant plastic thickness under the arched portions of the corresponding springs 68 to minimise the effects of shrinkage during curing.

The plastic for injection through the injection ports 76 is selected to exhibit predetermined physical characteristics after solidification including high Young's Modulus, for maximum torsional rigidity between the solid and tubular shaft ends, and minimum coefficient of friction, for minimum resistance to relative telescopic movement between the solid and tubular shaft ends. In a preferred embodiment, 30% glass fibre reinforced, 15% PTFE lubricated, Polyphenylene Sulphide Resin was found to exhibit acceptable physical characteristics.

After the in situ injection moulded plastic solidifies, the ends 34,46 and 36,48 are released for relative telescopic movement by simply fracturing the connection between the solidified plastic block 78 and the solidified plastic in the aforesaid passages defined by the registered ports 76 and slots 72. In addition, because the solid 36,48 and tubular 34,46 ends have substantial surface areas in sliding contact, application of conventional petroleum based lubricant between the ends after in situ injection moulding of the plastic blocks 78 has been found to further minimise sliding friction between the solid and tubular shaft ends.

The disclosures in United States patent application no. 068,519, from which this application claims priority, and the abstract accompanying this application, are incorporated herein by reference.

Claims

1. A variable length shaft assembly (24,28) including a first shaft (30,38); a second shaft (32,42); a polygonal tubular end (34,46) on the first shaft having a planar wall (50A,B); a correspondingly polygonal solid end (36,48) on the second shaft disposed in the polygonal tubular end for telescopic bodily movement relative thereto and for limited rotation relative thereto through an angular interval corresponding to linear clearances between the polygonal solid end and the polygonal tubular end; a spring chamber (66) in the polygonal solid end having a side open to the planar wall of the polygonal tubular end; and a spring (68) in the spring chamber having a flat body portion (70) bearing in sliding engagement against the planar wall of the polygonal tubular end and biasing the polygonal solid end and the polygonal tubular end in opposite directions to a substantially zero clearance relationship in which linear clearance between the polygonal solid end and the polygonal tubular end is reduced to substantially zero; characterised by an injection port (76) in the polygonal tubular end; a passage (72) from the injection port to the spring chamber behind the flat body portion of the spring; and a monolithic plastic block (78) moulded in situ in the spring chamber by introduction of liquid plastic through the passage capturing the zero linear clearance relationship between the polygonal solid end and the polygonal tubular end and defining a slide bearing therebetween and encasing the spring such that the flat body portion thereof defines a reinforced wear plate on the monolithic plastic block in sliding engagement on the planar wall of the polygonal tubular end.

2. A variable length shaft assembly as claimed in Claim 1, wherein the injection port (76) includes an orifice in the planar wall (50A,B) of the polygonal tubular end (34,46); and the pas-

sage includes a slot (72) in the flat body portion (70) of the spring (68) registering with the orifice in a predetermined longitudinal position of the polygonal solid end (36,48) relative to the polygonal tubular end.

3. A variable length shaft assembly as claimed in Claim 2, wherein the spring (68) is an arched spring including a pair of integral legs (74) at opposite ends of the flat body portion (70) bearing against a bottom wall (62) of the spring chamber (66) and resiliently biasing the polygonal solid end (36,48) and the polygonal tubular end (34,46) in opposite linear directions perpendicular to the planar wall (50A,B) to the substantially zero clearance relationship.

4. A motor vehicle steering system (10) including a steering column (18) having a tubular mast jacket assembly (20) adjustable in a length direction (22,L) of the steering column; a variable length column shaft assembly comprising a variable length shaft assembly as claimed in any one of Claims 1 to 3, wherein the first shaft (30) is rotatably supported on the mast jacket assembly and the second shaft (32) is rotatably supported on the mast jacket assembly; and a steering wheel (26) rigidly connected to one of the first and second shafts.

5. A motor vehicle steering system (10) including a steering gear (12) mounted on a chassis of a vehicle and having an input shaft (14) rotatably supported on a housing (16) of the steering gear; a steering shaft (30,32) rotatably supported on a steering column (18); and a variable length intermediate shaft assembly (28) comprising a variable length shaft assembly as claimed in any one of Claims 1 to 3, means (40) connecting one (38) of the first and the second shafts (38,42) to the steering shaft and means (44) connecting the other of the first and the second shafts to the input shaft.

Fig.1.

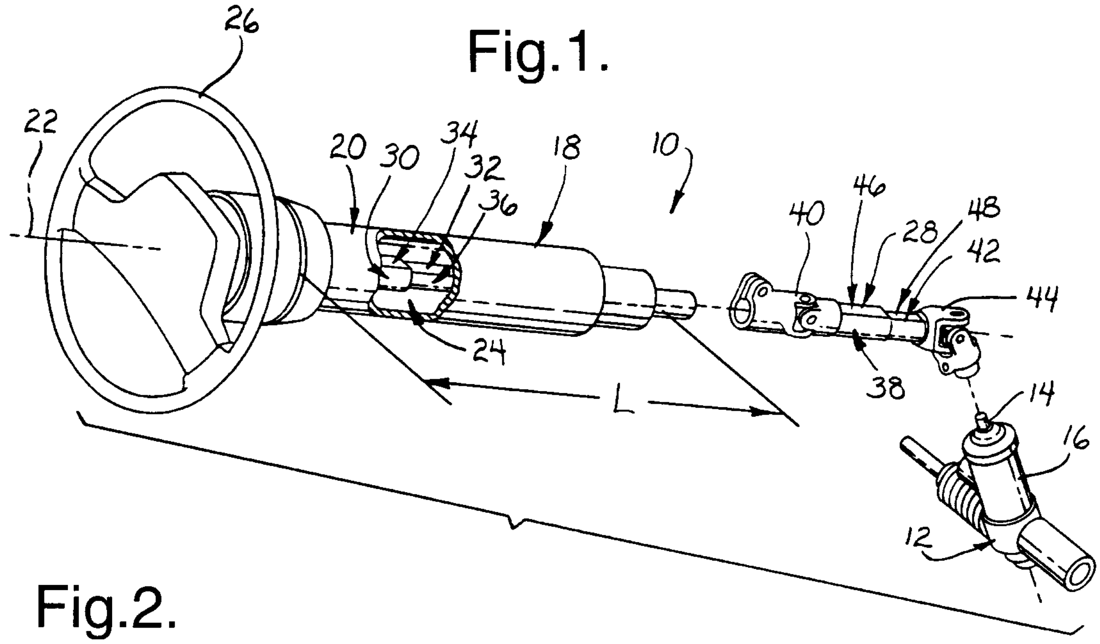


Fig.2.

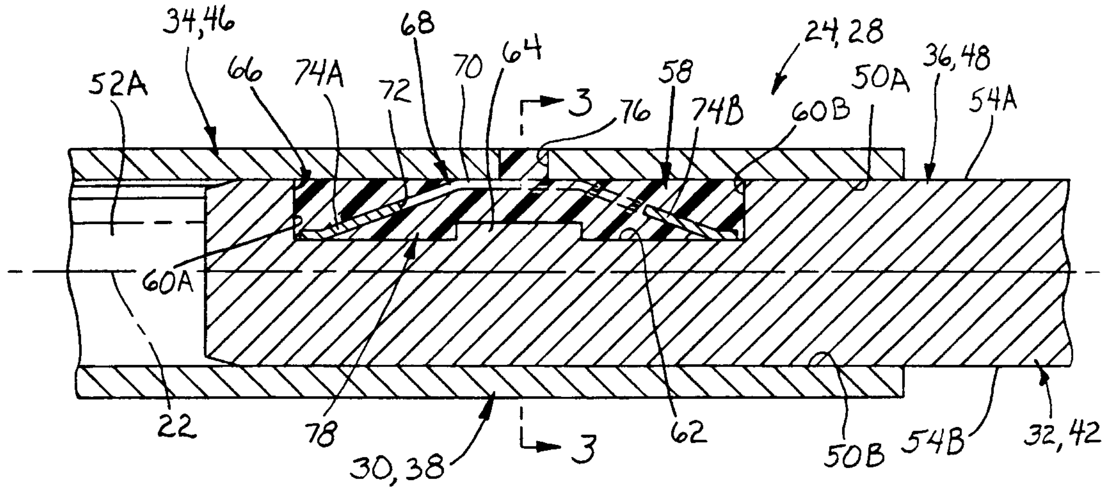
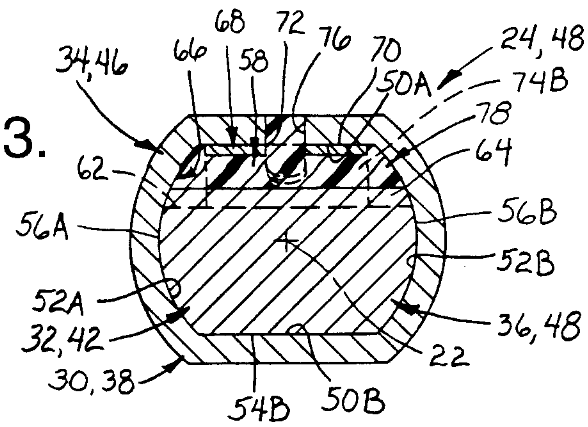


Fig.3.



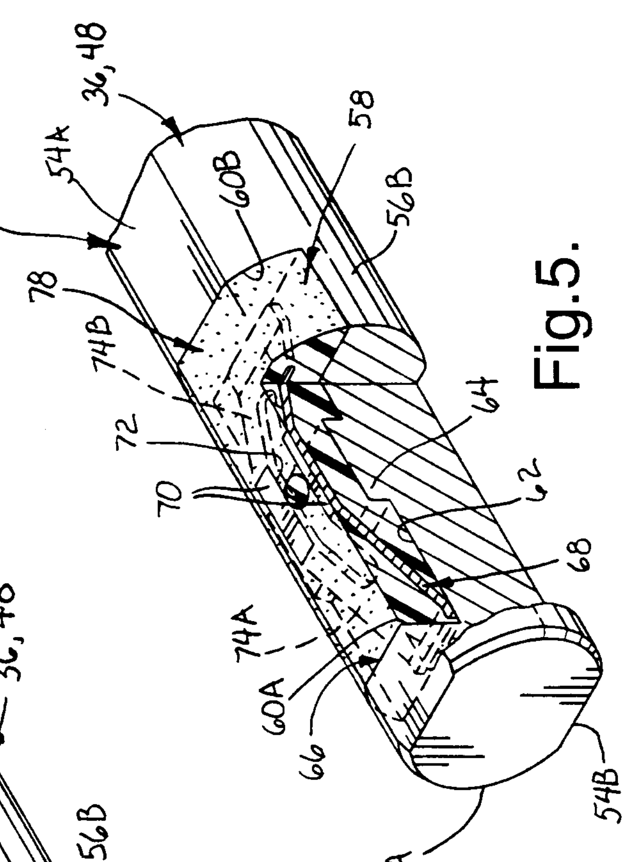
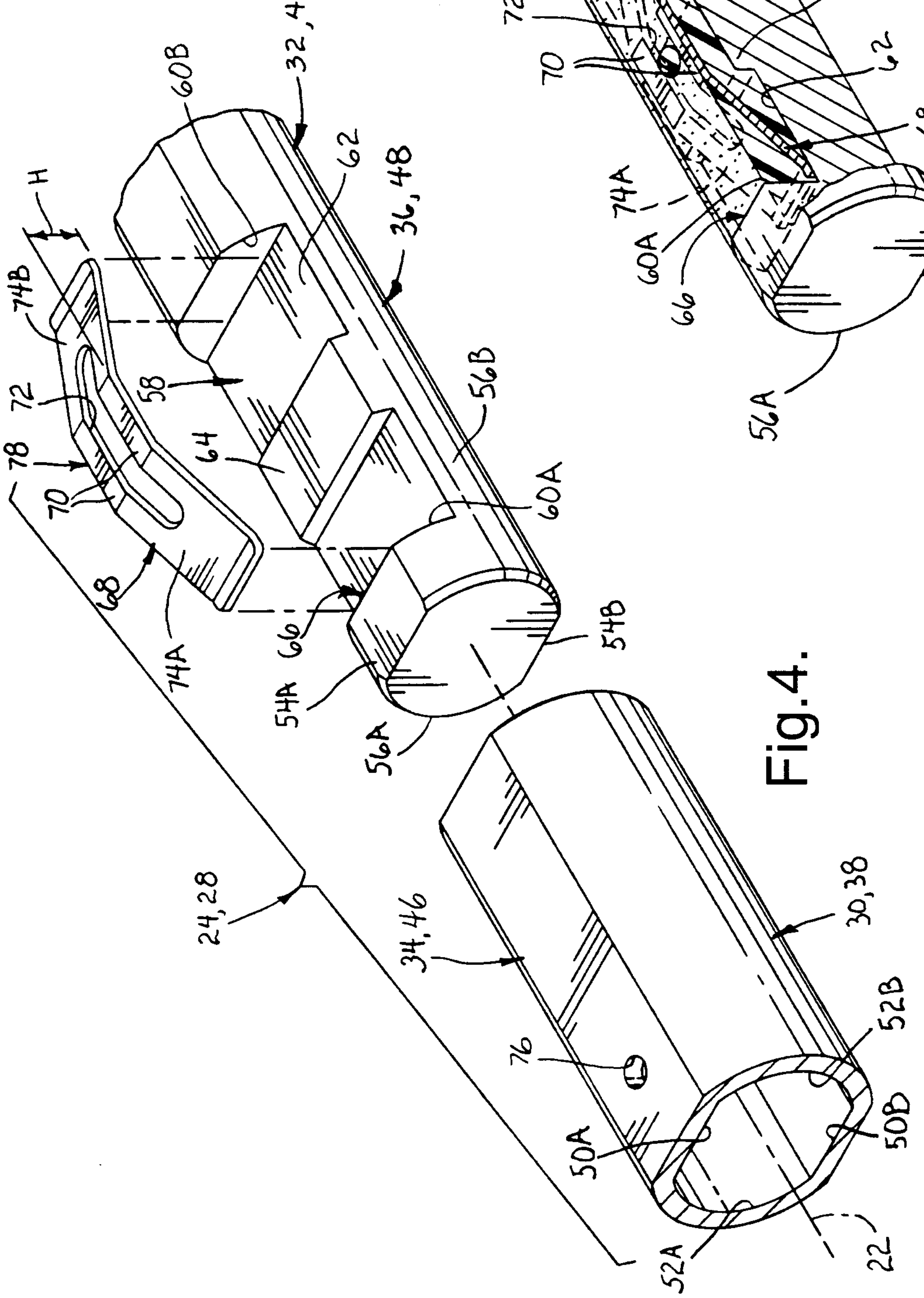

36,48
54A
32,42
58
60B
56B
78
74B
72
64
70
62
68
74A
60A
66
54B
56A

Fig.5.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70
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60A
68
74A
66
54B
54A
56A
24,28
34,46
30,38
76
50A
52B
50D
52A
22

Fig.4.